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LABORATORY AND FIELD TESTS OF ADDITIONAL ORGANIC
COMPOUNDS AGAINST THE EUROPEAN CORN BORER

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Laboratory investigations of organic compounds to establish their toxicities to newly hatched larvae of the European corn borer (Pyrausta nubilalis (Hbn.)) were begun at Toledo, Ohio, early in 1938. Tests with some of the more promising of these compounds have been conducted in the field. This report contains the results of laboratory tests from 1938 to the present on compounds not previously reported in publications E-557, E-612, E-620, and E-707 of this Bureau, and field tests for the years 1945, 1946, and 1947. All the compounds were supplied by the Division of Insecticide Investigations.

Laboratory Tests

The care and handling of moths, eggs, and larvae for these tests and the technique employed in conducting them are described in E-557. Materials were tested as sprays on fresh green cauliflower or corn leaves at the rate of 4 pounds of the compound per 100 gallons of water containing 1/3 pound of Areskap (sodium monosulfonate of butylphenylphenol) as a wetting agent. Many of these compounds had been mixed with equal parts of kaolin. These mixtures were evaluated at an application rate twice as great as that of the compounds which were not mixed with clay in order for the tests to be comparable. Materials showing high mortality with little or no feeding were retested at 2 pounds and 1 pound per 100 gallons of water. Larvae in all tests were given an opportunity to feed for 48 hours before mortality readings were taken. Results of these tests are given in tables 1, 2, and 3.

Of the 79 compounds tested at the rate of 4 pounds per 100 gallons of water, 3 gave 100 percent kill and 2 others gave mortality higher than 90 percent. Of the 3 most promising compounds, 2 continued to show 100 percent mortality when tested at 2 pounds per 100 gallons of water. At the rate of 1 pound per 100 gallons of water 3 compounds produced mortalities of 94 percent or higher.

Field Tests

The earliest planted fields of sweet corn were selected for these experiments. A wheelbarrow sprayer powered with a gasoline engine and equipped with a nozzle producing a solid cone of spray was used in applying the sprays. The plants were thoroughly treated, enough spray being applied to cause free run-off at the base of each plant. The quantities of spray were increased as the plants grew larger. Areskap was used as the wetting agent at the rate of $1/3$ pound per 100 gallons of water. Plots were randomized and replicated 4 times for each treatment. Dissections of 100 corn plants for each treatment were made at the roasting ear stage. The results are presented in table 4.

Table 1.--Tests at 4 pounds of compound per 100 gallons of water

Compound	Number of larvae used ^{1/}	Average percent mortality		Amount of feeding ^{2/}
		Treated	Not treated	
1-Phenylsemioxamazide <chem>C6H5NHNHCOCONH2</chem>	124	100	0.6	0
Bis(disalicylal)ethylenediamine, cobalt salt <chem>(CH2N:CHC6H4O)2Co</chem>	188	100	1.8	0
5-Methyl-1-phenylsemioxamazide <chem>C6H5NHNHCOCONHCH3</chem>	123	100	.6	0
Bis(2-hydroxy-3,5,6-trichlorophenyl) methane <chem>(C6HCl3OH)2CH2</chem>	95	97.9	2.0	+
2,4-Dichlorobenzamide <chem>C6H3Cl2CONH2</chem>	108	92.9	.5	0 - +
5-Ethyl-1-phenylsemioxamazide <chem>C6H5NHNHCOCONHC2H5</chem>	131	36.3	1.2	+++
alpha-Thiocyanoacetophenone <chem>C6H5COCH2SCN</chem>	97	18.6	.5	+++
N-Benzyl-m-nitrobenzamide <chem>NO2C6H4CONHCH2C6H5</chem>	79	14.8	0	+

^{1/} Approximately the same number of larvae were used in the nontreated check.

^{2/} 0 = none; + = little; ++ = moderate; +++ = much.

Table 1.-- Continued

Compound	Number of larvae used ^{1/}	Average percent mortality		Amount of feeding ^{2/}
		Treated	Not treated	
2,2',5'-Trichlorobenzanilide <chem>C6H4ClCONHC6H3Cl2</chem>	56	14.3	0.7	+++
2-Chloro-p-benzanilide <chem>C6H4ClCONHC6H4OCH3</chem>	69	13.4	.7	+++
p-Nitrobenzoic acid, 2,4,6-trichlorophenyl ester <chem>NO2C6H4COOC6H2Cl3</chem>	115	6.8	.9	+++
2-Chloro-o-benzanilide <chem>C6H4ClCONHC6H4OCH3</chem>	81	6.6	.7	+++
2,4-Dichloro-N-methylbenzamide <chem>C6H3Cl2CONHCH3</chem>	118	5.5	0	+++
2,2'-Dichlorobenzanilide <chem>C6H4ClCONHC6H4Cl</chem>	134	5.3	.4	+++
N-Amyl-o-chlorobenzamide <chem>C6H4ClCONHC5H11</chem>	105	4.9	0	+++
N,N-Dibenzyl-o-chlorobenzamide <chem>C6H4ClCON(CH2C6H5)2</chem>	87	4.5	.7	+++
N-Butyl-p-chlorobenzamide <chem>C6H4ClCONHC4H9</chem>	104	3.9	.9	+++
2-Chloro-4'-nitrobenzanilide <chem>C6H4ClCONHC6H4NO2</chem>	94	3.4	.7	+++
p-Nitrobenzoic acid, p-tolyl ester <chem>NO2C6H4COOC6H4CH3</chem>	93	3.2	1.0	+++
N,N-Dibenzyl-m-nitrobenzamide <chem>NO2C6H4CON(CH2C6H5)2</chem>	111	2.9	0	+++

Table 1.--Continued

Compound	Number of larvae used ^{1/}	Average percent mortality		Amount of feeding ^{2/}
		Treated	Not treated	
<i>o</i> -Chloro-N-cyclohexylbenzamide <chem>C6H4ClCONHC6H11</chem>	155	2.8	0.4	+++
2',5'-Dichloro-4-nitrobenzanilide <chem>NO2C6H4CONHC6H3Cl2</chem>	115	2.7	.9	+++
2,3'-Dichlorobenzanilide <chem>C6H4ClCONHC6H4Cl</chem>	162	2.5	.4	+++
N,N-Dibenzyl-p-nitrobenzamide <chem>NO2C6H4CON(CH2C6H5)2</chem>	80	2.3	0	+++
4-Nitrobenzanilide <chem>NO2C6H4CONHC6H5</chem>	122	2.2	.9	+++
<i>o</i> -Chloro-N-propylbenzamide <chem>C6H4ClCONHC3H7</chem>	138	2.2	1.0	+++
p-Nitro-N-propylbenzamide <chem>NO2C6H4CONHC3H7</chem>	97	2.2	1.0	+++
N-Cyclohexyl-p-nitrobenzamide <chem>NO2C6H4CONHC6H11</chem>	97	2.1	.9	+++
p-Chloro-N-propylbenzamide <chem>C6H4ClCONHC3H7</chem>	88	2.1	.9	+++
1-(<i>o</i> -Chlorobenzoyl)piperidine <chem>CH2(CH2)3CH2NCOOC6H4Cl</chem>	96	2.1	1.0	+++
4-Chlorobenzanilide <chem>C6H4ClCONHC6H5</chem>	111	2.0	.9	+++
3,4-Dichlorobenzamide <chem>C6H3Cl2CONH2</chem>	109	1.9	0	+++

Table 1.--Continued

Compound	Number of larvae used ^{1/}	Average percent mortality		Amount of feeding ^{2/}
		Treated	Not treated	
1-(p-Chlorobenzoyl)-2-phenylhydrazine <chem>C6H5NHNHCOC6H4Cl</chem>	168	1.9	0.4	+++
N-sec-Amyl-o-chlorobenzamide <chem>C6H4ClCONHCH(CH3)C3H7</chem>	185	1.8	.4	+++
2,4-Dichloro-N,N-dimethylbenzamide <chem>C6H3Cl2CON(CH3)2</chem>	121	1.7	0	+++
2-Chloro-3'-nitrobenzanilide <chem>C6H4ClCONHC6H4NO2</chem>	82	1.6	.7	+++
N-Benzyl-o-chlorobenzamide <chem>C6H4ClCONHCH2C6H5</chem>	123	1.6	1.0	+++
p-Nitrobenzoic acid, o-tolyl ester <chem>NO2C6H4COOC6H4CH3</chem>	131	1.6	1.0	+++
Bis(disalicylal)ethylenediamine, nickel salt <chem>(CH2N:CHC6H4O)2Ni</chem>	88	1.6	.9	+++
p-Nitrobenzoic acid, p-nitrophenyl ester <chem>NO2C6H4COOC6H4NO2</chem>	135	1.5	.9	+++
p-Chloro-N-isobutylbenzamide <chem>C6H4ClCONHCH2CH(CH3)2</chem>	86	1.3	.9	+++
p-Chloro-N-ethylbenzamide <chem>C6H4ClCONHC2H5</chem>	94	1.3	.4	+++
N-Benzyl-p-nitrobenzamide <chem>NO2C6H4CONHCH2C6H5</chem>	105	1.1	0	+++
1,1,1-Trichloro-2-methyl-2-propanol <chem>CCl3C(CH3)2OH</chem>	170	1.1	1.7	+++

Table 1.-- Continued

Compound	Number of larvae used ^{1/}	Average percent mortality		Amount of feeding ^{2/}
		Treated	Not treated	
p-Nitrobenzoic acid, 2,4-dichlorophenyl ester $\text{NO}_2\text{C}_6\text{H}_4\text{COOC}_6\text{H}_3\text{Cl}_2$	107	1.1	0.9	+++
1-(p-Nitrobenzoyl)piperidine $\text{CH}_2(\text{CH}_2)_3\text{CH}_2\text{NCOCC}_6\text{H}_4\text{NO}_2$	102	1.0	0	+++
Bis(p-chlorobenzyl)sulfone $(\text{ClC}_6\text{H}_4\text{CH}_2)_2\text{SO}_2$	94	1.0	.9	+++
2-Chloro-m-benzotoluide $\text{C}_6\text{H}_4\text{ClCONHC}_6\text{H}_4\text{CH}_3$	61	1.0	.7	+++
N-sec-Butyl-o-chlorobenzamide $\text{C}_6\text{H}_4\text{ClCONHCH}(\text{CH}_3)\text{C}_2\text{H}_5$	91	1.0	0	+++
o-Chloro-N-isopropylbenzamide $\text{C}_6\text{H}_4\text{ClCONHCH}(\text{CH}_3)_2$	97	1.0	1.0	+++
3'-Chloro-4-nitrobenzanilide $\text{NO}_2\text{C}_6\text{H}_4\text{CONHC}_6\text{H}_4\text{Cl}$	113	.9	.9	+++
N-sec-Butyl-p-chlorobenzamide $\text{C}_6\text{H}_4\text{ClCONHCH}(\text{CH}_3)\text{C}_2\text{H}_5$	104	.9	.9	+++
4'-Bromo-2-chlorobenzanilide $\text{C}_6\text{H}_4\text{ClCONHC}_6\text{H}_4\text{Br}$	91	.9	.7	+++
N-Butyl-o-chlorobenzamide $\text{C}_6\text{H}_4\text{ClCONHC}_4\text{H}_9$	101	.9	0	+++
p-Nitrobenzoic acid, m-tolyl ester $\text{NO}_2\text{C}_6\text{H}_4\text{COOC}_6\text{H}_4\text{CH}_3$	112	.9	.1	+++
2-Chloro-o-benzotoluide $\text{C}_6\text{H}_4\text{ClCONHC}_6\text{H}_4\text{CH}_3$	69	.9	.7	+++

Table 1.-- Continued

Compound	Number of larvae used ^{1/}	Average percent mortality		Amount of feeding ^{2/}
		Treated	Not treated	
N-Benzyl-p-chlorobenzamide <chem>C6H4ClCONHCH2C6H5</chem>	98	0.8	0.9	+++
N-Amyl-p-chlorobenzamide <chem>C6H4ClCONHC5H11</chem>	122	.8	.9	+++
4-(p-Nitrobenzoyl)morpholine <chem>CH2CH2OCH2CH2NCOCC6H4NO2</chem>	127	.8	0	+++
4-(p-Chlorobenzoyl)morpholine <chem>CH2CH2OCH2CH2NCOCC6H4Cl</chem>	140	.8	.4	+++
3',4-Dichlorobenzanilide <chem>C6H4ClCONHC6H4Cl</chem>	98	.8	.9	+++
p-Chlorobenzyl-p'-chlorophenyl sulfone <chem>ClC6H4CH2SO2C6H4Cl</chem>	110	.7	.9	+++
2-Chlorobenzanilide <chem>C6H4ClCONHC6H5</chem>	185	.4	.4	+++
2'-Chloro-4-nitrobenzanilide <chem>NO2C6H4CONHC6H4Cl</chem>	87	0	.9	+++
p-Nitrobenzoic acid, pentachlorophenyl ester <chem>NO2C6H4COOC6Cl5</chem>	115	0	.9	+++
Benzyl-p-chlorophenyl sulfone <chem>C6H5CH2SO2C6H4Cl</chem>	105	0	.9	+++
p-Chlorobenzyl phenyl sulfone <chem>ClC6H4CH2SO2C6H5</chem>	101	0	.9	+++
p-Chloro-N-cyclohexylbenzamide <chem>C6H4ClCONHC6H11</chem>	88	0	.9	+++

Table 1.-- Continued

Compound	Number of larvae used ^{1/}	Average percent mortality		Amount of feeding ^{2/}
		Treated	Not treated	
2-Chloro-p-benzotoluide $C_6H_4ClCONHC_6H_4CH_3$	82	0.0	0.7	+++
o-Chloro-N-isobutylbenzamide $C_6H_4ClCONHCH_2CH(CH_3)_2$	84	0	0	+++
4-(o-Chlorobenzoyl)morpholine $CH_2CH_2OCH_2CH_2NCOCC_6H_4Cl$	126	0	1.0	+++
p-Nitrobenzoic acid, p-tert- butylphenyl ester $NO_2C_6H_4COOC_6H_4C(CH_3)_3$	89	0	.9	+++
4'-Chloro-4-nitrobenzanilide $NO_2C_6H_4CONHC_6H_4Cl$	127	0	.9	+++
1-(p-Chlorobenzoyl)piperidine $CH_2(CH_2)_3CH_2NCOCC_6H_4Cl$	88	0	.9	+++
2',4-Dichlorobenzanilide $C_6H_4Cl_2CONHC_6H_4Cl$	73	0	.9	+++
4,4'-Dichlorobenzanilide $C_6H_4ClCONHC_6H_4Cl$	94	0	.9	+++
4-Chloro-2'-nitrobenzanilide $C_6H_4ClCONHC_6H_4NO_2$	75	0	.9	+++
Bis(disalicylal)ethylenediamine, copper salt $(CH_2N:CHC_6H_4O)_2Cu$	80	0	.9	+++
Bis(disalicylal)ethylenediamine, ferrous salt $(CH_2N:CHC_6H_4O)_2Fe$	97	0	.9	+++

Table 2.—Tests at 2 pounds of compound per 100 gallons of water

Compound	Number of larvae used ^{1/}	Average percent mortality		Amount of feeding ^{2/}
		Treated	Not treated	
1-Phenylsemioxamamide $C_6H_5NHNHCOCONH_2$	124	100	0.6	0
Bis(disalicylal)ethylenediamine, cobalt salt $(CH_2N:CHC_6H_4O)_2Co$	99	100	1.8	+
5-Methyl-1-phenylsemioxamamide $C_6H_5NHNHCOCONHCH_3$	129	97.5	.6	0 - +
Bis(2-hydroxy-3,5,6-trichloro- phenyl)methane $(C_6HCl_3OH)_2CH_2$	158	97.2	2.0	+
5-Ethyl-1-phenylsemioxamamide $C_6H_5NHNHCOCONHC_2H_5$	58	20.1	1.2	+++
2,4-Dichlorobenzamide $C_6H_3Cl_2CONH_2$	71	12.7	.5	+++

1,2/ See footnotes to table 1.

Table 3.—Tests at 1 pound of compound per 100 gallons of water

Compound	Number of larvae used ^{1/}	Average percent mortality		Amount of feeding ^{2/}
		Treated	Not treated	
1-Phenylsemioxamzide $C_6H_5NHNHCOC(=O)NH_2$	171	96.9	0.6	0 - +
5-Methyl-1-phenylsemioxamzide $C_6H_5NHNHCOC(=O)NHCH_3$	143	96	.6	+
Bis(2-hydroxy-3,5,6-trichloro-phenyl)methane $(C_6HCl_3OH)_2CH_2$	134	94.4	2.0	+
Bis(disalicylal)ethylenediamine, cobalt salt $(CH_2N:CHC_6H_4O)_2Co$	94	74.5	1.8	+ - ++
2,4-Dichlorobenzamide $C_6H_3Cl_2CONH_2$	63	4.8	.5	+++

1,2/ See footnotes to table 1.

Table 4.—Results of field tests with some of the more promising compounds as indicated in laboratory trials at Toledo, Ohio

Compound	Active ingredient per 100 gallons	Reduction of borers in		Injury to plant caused by compound
		Ears	Plants	
	<u>Pounds</u>	<u>Percent</u>	<u>Percent</u>	
<u>1945 Tests</u>				
DDT, (technical) 25 percent micronized on fuller's earth	0.5	98.9	99.2	None
2-Isobutyryl-1-phenylhydrazine 50 percent on kaolin	4.0	95.6	94.1	Moderate
1-Phenyl-2-phenylsulfonylhydrazine 50 percent on kaolin	4.0	98.9	93.7	Little
2-bis(3,5-Dichloro-2-hydroxyphenyl) 1,1,1-trichloroethane 50 percent on pyrophyllite	4.0	94.5	89.4	Little
1-Phenylsemioxamazine 50 percent on kaolin	4.0	95.6	89.0	Moderate
Bis(3,5,6-trichloro-2-hydroxy- phenyl)methane 50 percent on pyrophyllite	4.0	91.2	83.5	Moderate
1-Phenyl-2-(p-tolylsulfonyl)hydrazine 50 percent on kaolin	4.0	87.9	73.3	Moderate
<u>1946 Tests</u>				
DDT, (technical) 50 percent micronized on fuller's earth	1.0	96.7	93.8	None
2-Bis(3-bromo-5-chloro-2-hydroxyphenyl) 1,1,1-trichloroethane 33 percent on pyrophyllite	1.33	90.7	91.0	None
2-Bis(3,5-dichloro-2-hydroxyphenyl) 1,1,1-trichloroethane 50 percent on pyrophyllite	2.0	69.3	73.4	None
2-Bis(3-nitro-5-chloro-2-hydroxyphenyl) 1,1,1-trichloroethane 33 percent on pyrophyllite	1.33	40.0	43.3	None

Table 4.— Continued

Compound	Active ingredient per 100 gallons	Reduction of borers in		Injury to plant caused by compound
		Ears	Plants	
	<u>Pounds</u>	<u>Percent</u>	<u>Percent</u>	
<u>1947 Tests</u>				
1,1,1-Trichloro-2,2-bis(p-fluoro-phenyl)ethane 50 percent on kaolin	2.0	98.3	98.2	Little
DDT, (technical) 25 percent on clay	.5	96.4	97.2	None
Trichloromethyl-2,2'-methylene- bis(6-bromo-4-chlorophenyl) 50 percent on clay	2.0	91.9	91.4	None
1,1,1-Trichloro-2,2-bis(5-chloro-2- hydroxyphenyl)ethane 50 percent on clay	2.0	79.7	82.0	Little
Chloromethyl-4-chlorophenyl sulfone 50 percent on clay	2.0	77.7	75.3	None

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